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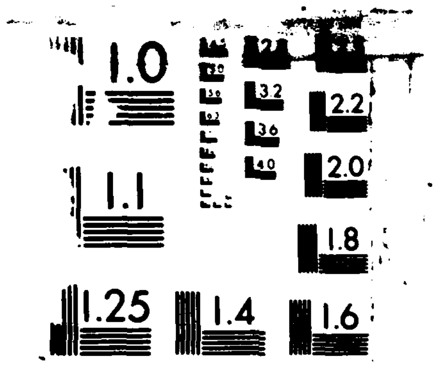

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AFWAL-TR-86-2061

DIESEL-ELECTRIC COGENERATING POWER PLANT ASSESSMENT FOR REMOTE SITE APPLICATIONS

Henry N. Chuang

University of Dayton Research Institute
300 College Park Avenue
Dayton, Ohio 45469

OCTOBER 1986

Final Report for Period August 1985 - December 1985

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This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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This program was directed toward assessing the Life Cycle Cost (LCC) of state-of-the-art diesel-electric cogenerating power plants at Air Force remote sites. This report assesses the LCC's of present and future diesel cogenerating plants for use at the Distant Early Warning Line (DEWLine) radar sites. The LCC consists of the fuel cost, acquisition cost, and the operation and maintenance cost. These costs were evaluated in constant 1985 dollars with no escalation or depreciation over a 20 year power plant life. The electrical size of the individual plants on the DEWLine ranged from 60 to 500 kilowatts (kW). The main emphasis of this study was on the 200 kW size power plants.

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Diesel-Electric Cogenerating Power Plant Assessment for Remote Site Applications

SUMMARY

INTRODUCTION

This program was directed toward assessing the Life Cycle Cost (LCC) of state-of-the-art diesel-electric cogenerating power plants at Air Force remote sites. This report assesses the LCC's of present and future diesel cogenerating plants for use at the Distant Early Warning Line (DEWLine) radar sites. The LCC consists of the fuel cost, acquisition cost, and the operation and maintenance cost. These costs were evaluated in constant 1985 dollars with no escalation or depreciation over a twenty year power plant life. The electrical size of the individual plants on the DEWLine ranged from 60 to 500 kilowatts (kW). The main emphasis of this study was on the 200 kW size power plants.

STUDY APPROACH

A set of parameters required in the assessment of each component of the life cycle cost were defined and presented.

(A) Two types of power plant operations were defined: main sites which normally required the simultaneous operation of two diesel cogenerating plants and auxiliary sites which required only one diesel cogenerating plant operating all the time.

(B) Two case studies using either the actual on-site electricity data from a main site, or estimated electricity consumption from an auxiliary site were presented. The space heating and hot water requirements were assumed to be at a flat, constant level for both cases. For the main site, actual acquisition costs for a set of five (5) engines in a recent (1985) project were used. The proposed labor schedule was assumed to be a two (2) man-crew working 54 hours a week and 52 weeks a year for main sites. The maintenance cost was projected from the actual FY85 average costs of main DEWLine sites equipped with older engine-generators. For the auxiliary site, actual (1985) acquisition costs for a set of 3 engines were used. Projected O & M costs from older engines at 4 DEWLine auxiliary sites with either 150 kW or 175 kW sets in Alaska and Canada were used to establish the life cycle cost for an auxiliary site. Life cycle costs of advanced cogenerating diesel-electric systems were also evaluated based on the projected future improvements on diesel-electric performance up to a maximum electrical generating efficiency of 50%.

(C) One more case study with the acquisition cost based on commercially available prepackaged modules was also presented.

PREFACE

This final technical report was prepared by the University of Dayton Research Institute under USAF Contract F33615-81-C-2011. The contract work was sponsored by the U.S. Air Force Wright Aeronautical Laboratories, Aero Propulsion Laboratory (AFWAL/POOA), Wright Patterson Air Force Base, Ohio. Mr. Steven Iden was the project manager. This report covers the period of 1 September 1985 to 31 December 1985.

The author wishes to acknowledge the generous support and technical assistance provided by Mr. S. Iden, Mr. J. Turner, and Lt J. P. Fellner of the Aerospace Power Division, Aero Propulsion Laboratory throughout the duration of this contract. Without their wise guidance, it would have been nearly impossible to sort out the many variables and remote site operating conditions to develop a clear set of important parameters required for evaluating the life cycle cost of diesel-electric cogenerating power plants at Air Force remote sites.

The author also wishes to acknowledge the generous support provided by Mr. W. E. Evans of the DEWLine Civil Engineering Office at Peterson AFB, Colorado. Volumes of operation and maintenance records of various diesel-electric cogenerating power plants were made available to the author. Through Mr. Evans' effort, a meeting with ITT FELEC Services, Incorporated was scheduled to discuss the various aspects of DEWLine power plant operations and the renovations planned for some Main and Auxiliary sites. Detailed insights were brought to discussion by Messrs R. McCuddy, C. Smith, K. Frazier, and F. Boskovich from ITT. It was very much appreciated.

Additional information provided by Captain M. Skomrock, an USAF officer on leave for full time study toward a PhD Degree in Mechanical Engineering at University of Dayton is also gratefully acknowledged.

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SECTION 1

COMPONENTS OF THE LIFE CYCLE COST AND VARIABLES WITHIN EACH COMPONENT

1-1 COSTS

All costs are evaluated in constant 1985 dollars with no escalation or depreciation over a 20 year operating period.

1-2 LIFE CYCLE COST (LCC)

LCC = Acquisition Cost + Fuel Cost + Operation & Maintenance (O&M) Costs

1-3 ACQUISITION COST

The acquisition cost consists of the following components and considerations:

Engine Cost: types, manufacturers, etc.

Heat Exchangers: types, manufacturers, etc.

Engine Module: cost of computer control system, switchgear, wiring, type of module construction, materials, labor, etc.

Total Freight: originating point, location of the site, air or sea lift, etc.

Site Preparation and Installation: location and condition of the site, man-hours required, labor rates, materials required, etc.

1-4 TOTAL FUEL COST OVER A 20 YEAR OPERATING PERIOD

The fuel cost consists of the following components and considerations:

Unit Cost ($/Gallon): location of the site, heat content, etc.

Cost of Fuel for Generating Electricity: annual kilowatt-hour (kWh) consumption at the site, electrical efficiency of the diesel generating system, etc.

Cost of Fuel for Generating Heat: space heating and domestic hot water loads, monthly kWh consumption profile, amount of waste heat contained in the engine cooling water and exhaust gas, efficiency of heat exchangers, etc. The cost of the auxiliary boiler is not included in the total acquisition cost listed in 1-3.

1-5 TOTAL O & M COSTS OVER A 20 YEAR POWER PLANT LIFE

The O & M cost consists of the following components and considerations:

Total Cost of Lube Oil: location of the site, number of oil changes, etc.

Total Parts Cost: mean time between failure and established maintenance schedule, location of the site, etc.

Total Labor Cost: location and type of site

1-6 NUMBER OF ENGINE-GENERATORS

Two scenarios satisfy the power requirements of most of the main and auxiliary sites.

Main Sites: Five 200 kW engines; two are operating all the time, two on hot stand-by, and one on scheduled maintenance.

Auxiliary Sites: Three 200 kW engines; one operating all the time, one on hot stand-by, and one on scheduled maintenance.

1-7 ENGINE-GENERATOR SYSTEM PERFORMANCE, 1985 AND 1990

1985 Base Year:

DFA is assumed, at 133,500 Btu/Gal.

A 60-70% average diesel engine load is assumed.

A performance of 14 kWh/Gal is assumed, corresponding to a generating efficiency of 35.8%, which has been demonstrated in newer engine-generator systems.

SECTION 2

CASE STUDIES

The life cycle cost of cogenerating power plants used to produce electricity and heat consists of three components. They are (1) fuel cost (the delivered fuel cost for both the auxiliary boiler and the cogenerator), (2) acquisition cost, and (3) the operating and maintenance cost.

The acquisition cost is represented by the following items:

Total cost for engine-generators, heat exchangers, silencers, pumps, etc.
Engine module (including switchgear, computer controls, etc.)
Freight (sealift or airlift)
Site preparation and installation

The cost of delivered arctic diesel fuel (DFA) fuel is assumed to be $2.02 per gallon (excluding CAM-4, CAM-5, DYE-2, and DYE-3) and has a higher heating value of approximately 133,500 Btu per gallon.

Operating cost data from 26 sites (6 main and 21 auxiliary sites in Alaska and Canada) were examined and analyzed. The four sites in Greenland (DYE 1, DYE 2, DYE 3 and DYE 4) were not included in the study.

The operating and maintenance costs consists of lube oil, parts, and labor cost. The cost of delivered lube oil is approximately $4.48 per gallon for most of the 26 sites. Since it is difficult to acquire the actual cost for parts in a life span of 20 years, an alternative method is developed to estimate the oil and part costs. It is assumed that the engine-generator sets (ranging from 60 kW to 500 kW, and from less than one year old to more than 30 years old) were at various stages of the maintenance cycle during FY 85. The average lube oil and parts cost of the four main sites is, approximately, 1.5 cents/kWh. With the new 1985 Cummins 200 kW engine-generator sets, it is assumed that the average cost of oil and parts should be less than 1.5 cents/kWh.

Four auxiliary sites (LIZ 2, LIZ 3, POW 1, and POW 2, all located in Alaska) are equipped with either 150 kW or 175 kW diesel-generators which is close to the 200 kW size selected for this study. The average FY 85 cost of lube oil and parts for these sites was approximately 1.25 cents/kWh. The average O & M costs for the same four sites was established at 2.34 cents/kWh. With the new 200 kW Cummins diesel-generator system (with some advantages from economy of size), it is assumed that both lube oil, parts and labor cost will be somewhat lower than the actual FY 85 cost data previously described. Therefore, a lower figure of 1.5 cents/kWh (versus 2.34 cents/kWh) in average O & M costs is assumed for those auxiliary sites equipped with new 200 kW diesel-generator systems.

The labor cost associated with the operation of a main site is regulated by Air Force regulations. Four operators are required, each working 54 hours a week, 52 weeks a year. The labor rates in FY85 were established at $41 an hour for sites located in Alaska (including overtime pay), and $28.75 an hour for sites in Canada. With the new 200 KW Cummins replacement diesel-electric modules currently being installed in various sites, the contractor proposed to operate with a 2-man crew by taking advantage of the modern computer control equipment. Assuming a 2-man crew, the life cycle labor cost is estimated at $4,605,000 for Alaskan operation, and $3,229,000 for Canadian operation.

2-1 MAIN SITE IN CANADA (CAM-MAIN), USING 1985 TECHNOLOGY AND COSTS

(A) Acquisition Cost (five new 1985 Cummins 200 kW units):

Total cost for engine, heat exchangers, modules (including switchgear, computer controls, etc.):	$1,160,000
Freight (sealift):	$ 60,000
Site preparation and installation:	$ 230,000
Total acquisition cost:	$1,450,000

(B) CAM-MAIN FY85 operation: 2,241,120 kWh (with five 150 kW units)
Projected for 20 years: 44,822,400 kWh

(C) Estimated lube oil and parts costs: $672,000 at 1.5 cents/kWh

(D) Estimated fuel cost based on $2.02/Gallon and 14 kWh/Gallon demonstrated by the performance of relatively new engine-generator systems: 3,201,600 gallons, and $6,467,000 for 20 years of operation

(E) Summary:

Acquisition Cost:	$ 1,450,000	(12%)	3.2	cents/kWh
O&M Costs:	$ 672,000	(6%)	1.5	cents/kWh
Labor Costs:	$ 3,229,000	(27%)	7.2	cents/kWh
Fuel Cost:	$ 6,467,000	(55%)	14.4	cents/kWh
Life Cycle Cost:	$11,818,000	(100%)	26.3	cents/kWh

(F) Remarks: The higher labor cost in Alaska would raise the life cycle to $13,194,000, or 29.4 cents/kWh in average electricity cost.

2-2 MAIN SITE IN CANADA (CAM-MAIN) AT VARIOUS GENERATING EFFICIENCIES UP TO A MAXIMUM OF 50%

It is assumed that the available waste heat from engine exhaust gas and cooling water is more than what is actually required for space heating and domestic hot water needs. The auxiliary boilers were never operated in FY85 in 29 of the 31 sites. As a matter of fact, considerations have been given to provide space heating for outer buildings (warehouse and garage) with the surplus waste heat. Therefore, it is assumed that the space heating and hot water requirements of these remote sites are likely at 80 to 90% of the available waste heat. The available waste heat is defined as the balance of 80% and system generating efficiency. For example, at a system generating efficiency of 35.8% (corresponding to 14 kWh per gallon of DFA), the available waste heat is estimated at 44.2% of the higher heating value of the DFA fuel.

The remaining 20% is assumed to be lost through exhaust gas, cooling water, and the inefficiency of heat exchanger and other components. In case that the available waste heat is insufficient to meet the requirement, the auxiliary boiler would have to be operated.

(A) Assumptions:

The actual space heating and hot water requirements are a flat, constant 708 million Btu's per month or an overall thermal/electric ratio of 1.11.

A boiler efficiency of 80%.

Same acquisition cost for the more advanced diesel-generator systems (using advanced technology and computer controls) for easy comparisons.

Engine generating efficiency of 35.8% (1985), 40% (15.6 kWh/Gal), 45% (17.6 kWh/Gal), and 50% (19.6 kWh/Gal).

Acquisition cost = $1,450,000. Lube oil & parts cost = $672,000.
Labor cost = $3,229,000. Delivered fuel cost: $2.02 per gallon.

All Figures in 1,000	Engine-Generator Efficiency			
	35.8% 14 kWh/Gal	40% 15.6 kWh/Gal	45% 17.6 kWh/Gal	50% 19.6 kWh/Gal
Engine Fuel (Gallons)	3,202	2,865	2,546	2,292
Engine Fuel Cost	$ 6,467	$ 5,787	$ 5,144	$ 4,630
Boiler Fuel (Gallons)	0	161	480	734
Boiler fuel Cost	$ 0	$ 326	$ 969	$ 1,483
Total Fuel Cost	$ 6,467	$ 6,113	$ 6,113	$ 6,113
Summary:				
Acquisition Cost	$ 1,450(12%)	$ 1,450(13%)	$ 1,450	$ 1,450
Lube Oil & Parts Cost	$ 672(6%)	$ 672(6%)	$ 672	$ 672
Labor Cost	$ 3,229(27%)	$ 3,229(28%)	$ 3,229	$ 3,229
Total Fuel Cost	$ 6,467(55%)	$ 6,113(53%)	$ 6,113	$ 6,113
Life Cycle Cost (LCC)	$11,818	$11,464	$11,464	$11,464

As can be seen, the life cycle cost is almost independent of the diesel-electric electrical efficiency based on the assumptions made. The higher the engine-generator efficiency, the less the available waste heat for space heating. Therefore, the total amount of fuel required for providing both electricity and space heating services remains about the same when the engine-generator efficiency is greater than 40%. The unit cost of electricity generated is summarized as follows:

System Performance:	14 kWh/Gallon	15.6+ kWh/Gallon
Acquisition Cost:	3.2 cents/kWh	3.2 cents/kWh
O & M Costs:	1.5 cents/kWh	1.5 cents/kWh
Labor Cost:	7.2 cents/kWh	7.2 cents/kWh
Total Fuel Cost:	14.4 cents/kWh	13.6 cents/kWh
Life Cycle Cost:	26.3 cents/kWh	25.5 cents/kWh

2-3 AUXILIARY SITE IN ALASKA (POW-2) USING 1985 TECHNOLOGY AND COST FIGURES

(A) Acquisition Cost (based on three new 1985 Cummins 200 kW units):

Total cost for three engine-generators, heat exchangers, and modules (including switchgear, computer controls, etc.):	$690,000
Freight (sealift):	$ 60,000
Site preparation and installation:	$170,000
Total acquisition cost:	$920,000

(B) FY 85 operation: 1,120,623 kWh (with three 175 kW units)
Projected for 20 years: 22,412,460 kWh

(C) Estimated O & M costs: at 1.5 cent/kWh or $336,000

(D) Estimated fuel cost based on $2.02/Gallon and 14 kWh/Gallon demonstrated by the performance of relatively new engine-generator systems:

1,600,890 gallons or $3,234,000 for 20 years of operation

(E) Summary:

Acquisition Cost:	$ 920,000	(20%)	4.1 cents/kWh
O & M Costs:	$ 336,000	(8%)	1.5 cents/kWh
Fuel Cost:	$3,234,000	(72%)	14.4 cents/kWh
Total Cost:	$4,490,000	(100%)	20.0 cents/kWh

2-4 AUXILIARY SITE IN ALASKA (POW-2) AT VARIOUS GENERATING EFFICIENCIES UP TO A MAXIMUM OF 50%

It is assumed that the heating and hot water required for an auxiliary site is about 354 million BTU's per month. The other assumptions related to the main plants are also applicable to the auxiliary sites.

Acquisition cost = $920,000. O & M cost = $336,000.
Delivered fuel cost: $2.02 per gallon.

All Figures in 1,000	Engine-Generator Efficiency			
	35.8% 14kWh/Gal	40% 15.6kWh/Gal	45% 17.6kWh/Gal	50% 19.6 kWh/Gal
Engine Fuel (Gallons)	1,601	1,432	1,273	1,146
Engine Fuel Cost	$ 3,234	$ 2,893	$ 2,572	$ 2,315
Boiler Fuel (Gallons)	0	80	239	366
Boiler fuel Cost	$ 0	$ 162	$ 483	$ 740
Total Fuel Cost	$ 3,234	$ 3,055	$ 3,055	$ 3,055
Summary:				
Acquisition Cost	$ 920(20%)	$ 920(21%)	$ 920	$ 920
O & M Costs	$ 336(8%)	$ 336(8%)	$ 336	$ 336
Total Fuel Cost	$ 3,234(72%)	$ 3,055(71%)	$ 3,055	$ 3,055
Life Cycle Cost (LCC)	$ 4,490	$ 4,311	$ 4,311	$ 4,311

As can be seen, the life cycle cost is almost independent of the engine-generator system efficiency based on the assumptions made.

The unit cost of electricity generated is summarized as follows:

System Performance:	14 kWh/Gallon	15.6+ kWh/Gallon
Acquisition Cost:	4.1 cents/kWh	4.1 cents/kWh
O & M Costs:	1.5 cents/kWh	1.5 cents/kWh
Total Fuel Cost:	14.4 cents/kWh	13.6 cents/kWh
Life Cycle Cost:	20.0 cents/kWh	19.2 cents/kWh

2-5 AUXILIARY SITES USING ACQUISITION COST BASED ON COMMERCIALLY AVAILABLE OFF-THE-SHELF MODULES AT VARIOUS GENERATING EFFICIENCIES UP TO A MAXIMUM OF 50%

(A) Acquisition cost is based on $600/kW (as estimated by the author) for the modules.

Total cost for three engine-generators, heat exchangers, and modules (including switchgear, computer controls, etc.):	$360,000
Freight (sealift):	$60,000
Site preparation and installation:	$170,000
Total acquisition cost (about $983 per kW):	$590,000

(B) kWh generated over a period of 20 years: 22,412,460 kWh

(C) Estimated O & M costs at a ceiling of 1.5 cent/kWh: $336,000

(D) Estimated fuel cost based on 14 kWh/Gallon: $3,234,000
for 20 years of operation

All Figures in 1,000	Engine-Generator Efficiency			
	35.8% 14 kWh/gal	40% 15.6 kWh/gal	45% 17.6 kWh/gal	50% 19.6 kWh/gal
Engine Fuel (Gallons)	1,601	1,432	1,273	1,146
Engine Fuel Cost	$ 3,234	$ 2,893	$ 2,572	$ 2,315
Boiler Fuel (Gallons)	0	80	239	366
Boiler fuel Cost	$ 0	$ 162	$ 483	$ 740
Total Fuel Cost	$ 3,234	$ 3,055	$ 3,055	$ 3,055
Summary:				
Acquisition Cost	$ 590(14%)	$ 590(15%)	$ 590	$ 590
O & M Costs	$ 336(8%)	$ 336(8%)	$ 336	$ 336
Total Fuel Cost	$ 3,234(78%)	$ 3,055(77%)	$ 3,055	$ 3,055
Life Cycle Cost (LCC)	$ 4,160	$ 3,981	$ 3,981	$ 3,981

As can be seen, the life cycle cost is almost independent of the engine-generator system efficiency based on the assumptions made.

The unit cost of electricity generated is summarized as follows:

System Performance:	14 kWh/Gallon	15.6+ kWh/Gallon
Acquisition Cost:	2.6 cents/kWh	2.6 cents/kWh
O & M Costs:	1.5 cents/kWh	1.5 cents/kWh
Total Fuel Cost:	14.4 cents/kWh	13.6 cents/kWh
Life Cycle Cost:	18.5 cents/kWh	17.7 cents/kWh

SECTION 3

INTERPRETATION OF THE CASE STUDIES

3-1 The freight and installation costs are relatively insignificant, on the order of 2.5% of the Life Cycle Cost for main sites, and 6% of the Life Cycle Cost for auxiliary sites.

3-2 The total fuel cost (engine and auxiliary boiler) is the dominant factor in the Life Cycle Cost. It varies from approximately one-half of the Life Cycle Cost in main sites, to approximately 80% of the Life Cycle Cost in auxiliary sites.

3-3 The labor cost is quite significant in main sites (at about 27-28% of the LCC, second only to the total fuel cost) due to Air Force regulations on manning.

3-4 The labor cost is relatively insignificant in auxiliary sites. The O&M cost (including lube oil, parts and labor) is approximately 1.5 cents/kWh.

3-5 The lube oil and parts cost is estimated at 1.5 cents/kWh or less for main sites.

3-6 The total acquisition cost can be reduced by acquiring commercially available prepackaged units instead of specially assembled modules if they can satisfy the harsh requirements for arctic operations and the unique power plant control requirements. The present criterion for DEWLine operation specifies to withstand minus 60 ^{o}F temperature and 170 mph winds. However, if the power plant is to be housed inside a protective shed, as in many of the sites at the present time, the commercially available prepackaged units should be able to perform satisfactorily. One more concern is raised on whether the commercially available computer control system can function in all of the areas to match the performance of the specially packaged Cummins system. If the commercial package can meet the control specification, then special packaging costs are not incurred and the acquisition cost will be lower. Based on discussions with representatives of several companies at the 8th World Energy Engineering Conference (October 1985 at Atlanta), the unit acquisition cost will probably be less than $1,000/kW as compared to $1,500/kW described in the previous section.

SECTION 4

RECOMMENDATIONS ON POTENTIAL FUTURE RESEARCH WORK BASED ON THE FINDINGS CONTAINED IN THIS REPORT

4-1 Actual monthly space heating, hot water, and electricity profile of several sites (Alaskan Air Command and DEWLine sites) should be solicited. The procedures outlined in Section 2 can be used to develop several actual case studies.

4-2 Case study of several other sites in temperate and hot climate regions can be developed.

4-3 Based on findings from those case studies, a generalized study can be developed to study the impact of the ratio of the thermal/electric energy needed at a site on the life cycle cost.

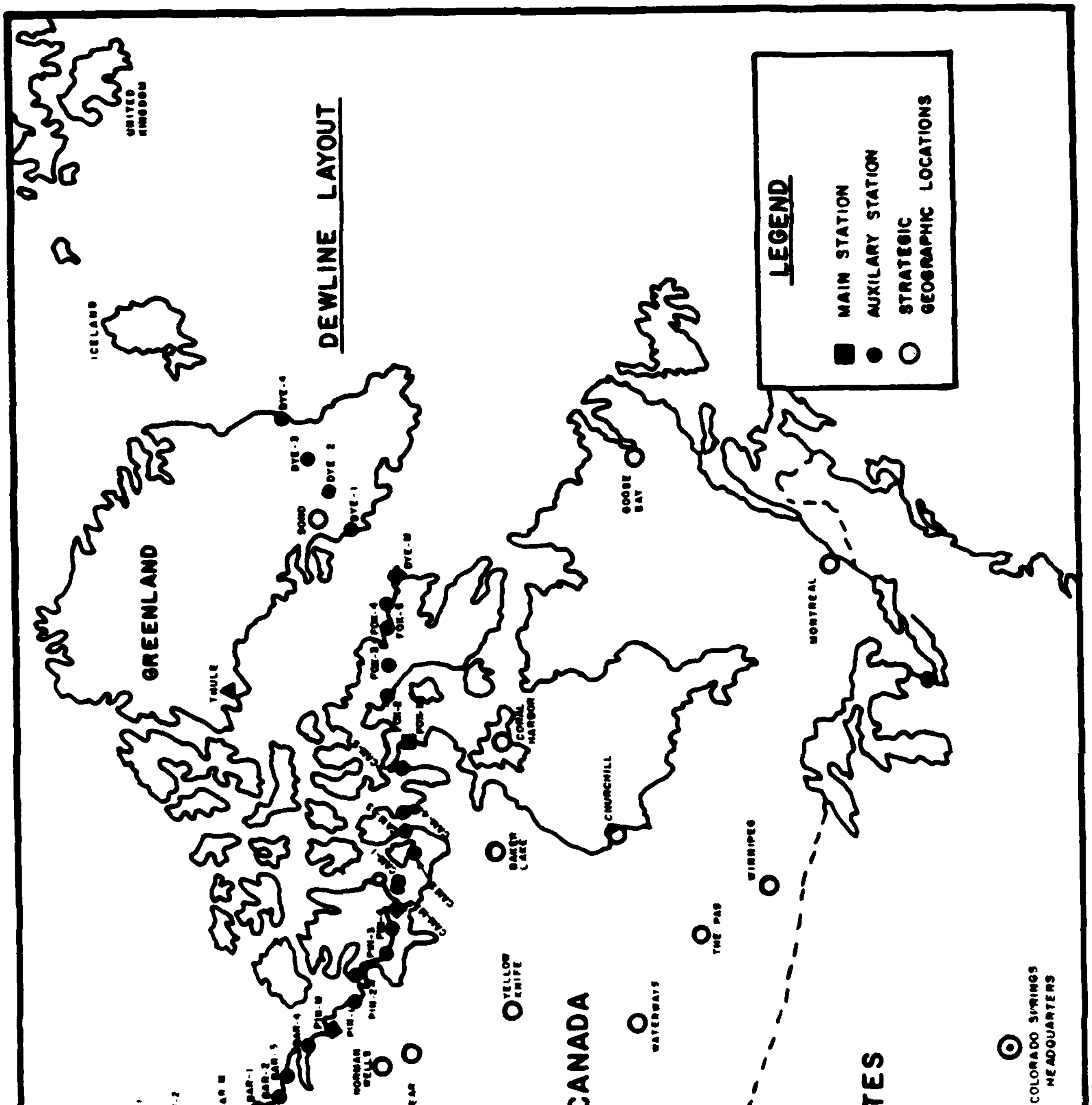
4-4 Investigate, for cost-effectiveness, how to reduce the acquisition cost through acquiring commercially available prepackaged engine-generator modules.

REFERENCES

5-1 LOCATION MAP OF DEWLINE SITES LAYOUT

5-2 FY85 DEWLINE POWER PLANT OPERATING COSTS STATISTICS

5-3 ESTIMATED MONTHLY KWH USAGE AND OTHER OPERATING STATISTICS OF SIX DEWLINE AUXILIARY POWER PLANTS: LIZ 2, POW 2, BAR 4, PIN 4, CAM 5 AND FOX 4


DEWLINE LAYOUT
LEGEND
MAIN STATION
AUXILARY STATION
STRATEGIC GEOGRAPHIC LOCATIONS
GREENLAND
ICELAND
UNITED KINGDOM
ALASKA
CANADA
UNITED STATES
THULE
DYE-4
DYE-3
DYE 2
DYE-1
GOOSE BAY
MONTREAL
CORAL HARBOR
CHURCHILL
BAKER LAKE
WINNIPEG
THE PAS
YELLOW KNIFE
WATERWAYS
NORMAN WELLS
GREAT BEAR
SEATTLE McCHORD
COLORADO SPRINGS HEADQUARTERS

FY85

DEWLINE
POWER PLANT OPERATING COST FY85
01 JULY 1984 THRU 30 JUNE 1985

SITE	FUEL USED (USG)	FUEL COST	LUBE-OIL USED (USG)	LUBE OIL COST	PARTS COST	LABOR COST	KWH	CAPITAL INVESTMENT
LIZ-2	92960	187779.20	487	2181.76	5078.85	7874.17	1052590	482000.00
LIZ-3	79455	160499.10	464	1998.08	8218.44	9017.03	982186	482000.00
POW-M Nat Gas MCF	20747	12628.60						
POW-M DFA	63141	127544.82	998	4471.04	16223.28	43586.07	1487624	898000.00
POW-1	92090	186021.80	563	2522.24	21757.14	17469.43	1032906	440000.00
POW-2	92125	186092.50	432	1935.36	8762.59	11308.90	1120623	700850.00
BAR-M 175KW 400KW	204246	412576.92	4456	19962.88	28248.89	432749.11	2335373	2475000.00
BAR-1	87449	176646.98	741	3319.68	18364.50	13342.03	926776	738000.00
BAR-2	95760	193435.20	808	3619.84	11740.53	21640.72	867514	572000.00
BAR-3	107805	217766.10	879	3937.92	11364.76	17398.28	1074008	589000.00
BAR-4	84945	171588.90	710	3180.80	10642.28	11004.29	877090	837000.00
PIN-M	142829	288514.58	1036	4641.28	11740.72	319384.28	1711923	663000.00
PIN-1	86304	174334.08	716	3207.68	8425.87	12542.20	901314	611000.00
PIN-2	96857	195651.14	795	3561.60	17631.67	14399.41	907667	632000.00
PIN-3	97140	196222.80	743	3328.64	26582.82	19737.67	1080314	518000.00
PIN-4	85050	171801.00	692	3100.16	12390.04	13634.38	921129	538000.00
CAM-M	190531	384872.62	1445	6473.60	12011.27	312983.48	2241120	1305000.00
CAM-1	90390	182587.80	775	3472.00	13229.24	11756.88	913496	601000.00
CAM-2	90740	183294.80	697	3122.56	4816.90	9980.21	830896	606000.00
CAM-3	106185	214493.70	823	3687.04	6005.07	14319.40	905394	607000.00
CAM-4	100070	256179.20	694	4032.14	29560.50	16300.10	1011640	931000.00
CAM-5	100010	256025.60	794	4613.14	7765.17	15291.75	990455	850000.00
FOX-M	327917	662392.34	2080	9318.40	70300.19	323421.84	4387000	2927000.00
FOX-2	86605	174942.10	780	3494.40	6258.32	12890.68	989349	961000.00
FOX-3	97540	249702.40	842	4892.02	15477.87	12563.16	949647	835000.00
FOX-4	107895	217947.90	755	3382.40	8900.03	20420.66	1057410	793000.00
FOX-5	84585	170861.70	766	3431.68	16621.02	18006.52	894310	676000.00
DYE-M U/C	183310	370286.20	1200	5376.00	40093.25	335879.27	2299100	1731000.00
DYE-M L/C	97554	197059.08	516	2311.68	1701.65	7055.17	767135	381000.00
DYE-1	244067	493015.34	1879	8417.92	100942.20	119282.88	2853430	386000.00
DYE-2	232949	694188.02	2556	14850.36	142417.45	129117.12	2616900	302000.00
DYE-3	238514	710771.72	2337	13577.97	35968.90	132116.88	2521950	307000.00
DYE-4	303387	612841.74	3126	14004.48	99294.15	129117.12	3823200	510000.00
TOTAL 84-85 NAT GAS MCF	20747	12628.60						
DFA	4190405	9077937.38	36585	173426.75	828535.56	2585591.09	47331469	25879850.00
TOTAL 83-84 NAT GAS MCF	24682	15154.74						
DFA	4525256	10580921.98	39010	181262.73	996411.58	2445565.64	49296972	16960000.00

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FY 85 DEWLINE AUXILIARY PLANTS

The monthly Kwh usage are estimated as per DL Form 258 Instruction Item 2A

	LIZ 2 3 X 150 KW			POW 2 3 X 175 KW			RAR 4 5 X 60 KW			PIN 4 5 X 60 KW			CAM 5 5 X 60 KW	FOX 4 5X60KW
	KWH	GAL	KWH/G	KWH	GAL	KWH/G	KWH	GAL	KWH/G	KWH	GAL	KWH/G	KWH	KWH
JUL	86800	7495	11.6	81840	8340	9.8	72692	6840	10.6	59760	6055	9.9	76790	84720
AUG	84320	7850	10.7	83328	7390	11.3	71472	7670	9.3	62992	5035	10.8	83700	89032
SEP	86400	7875	11.0	83135	7410	11.2	68400	7300	9.4	61381	7840	7.8	78552	89280
OCT	91760	7375	12.4	93000	8130	11.4	61572	6795	9.1	75600	7620	9.9	83220	90000
NOV	96250	7640	12.6	97000	7460	13.0	71060	7660	9.4	83823	7575	11.1	80760	95232
DEC	98460	8455	11.6	100440	7600	13.2	86970	6900	12.6	83519	7750	10.8	85684	88320
JAN	91760	7470	12.3	100440	7585	13.2	82774	7215	11.5	77128	7855	9.8	93487	93744
FEB	76160	8165	9.3	94080	8220	11.4	81390	7060	11.5	91512	8080	11.3	84874	97464
MAR	95480	7745	12.3	100440	7350	13.7	65800	5660	11.6	67200	7090	9.5	83570	81970
APR	79200	7810	10.1	97200	7580	12.8	75600	7840	9.6	85642	6370	13.4	80500	87792
MAY	86800	7345	11.8	99720	7650	13.0	71580	6815	10.5	86436	6815	12.7	82478	84960
JUN	79200	7735	10.2	90000	7410	12.1	66960	7190	9.3	86136	6160	14.0	76840	74896
TOTAL	1052590 KWH			1120623 KWH			877090 KWH			921129 KWH			990455 KWH	1057410
	92960 GAL			92125 GAL			84945 GAL			85050 GAL			100010 GAL	107895
	11.3 KWH/G			12.2 KWH/G			10.3 KWH/G			10.8 KWH/G			9.9 KWH/G	9.8
$FUEL	$187779			$186092			$171589			$171801			$256026	$217948
	($2.02)			($2.02)			($2.02)			($2.02)			($2.56)	($2.02)
PARTS	$ 7261			$ 10698			$ 13823			$ 15490			$ 12378	$ 12282
LABOR	$ 7874			$ 11309			$ 11004			$ 13634			$ 15292	$ 20421
TOTAL	$ 15135			$ 22007			$ 24827			$ 29124			$ 27670	$ 32703

FOR 21 AUXILIARY SITES:

FUEL	-- $4,071,202	(1,961,960 GAL)	
LUBE OIL	-- $ 68,982	(11%)	
PARTS	-- $ 269,594	(42%)	
LABOR	-- $ 300,898	(47%)	TOTAL MAINTENANCE: $639,474

KWH GENERATED — 20,286,714 KWH; AVE. O & M COST- 3.15 CENTS/KWH; AVE. FUEL COST - 20.07 CENTS/KWH

*U.S.Government Printing Office 1987 - 748-071/60720

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